Improving Learning in Education

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Educators face many challenges, one of which is: How do students learn how to learn and what strategies are good for learning? Although children are natural learners from the day they are born, most seem ill-equipped for learning the kinds of material taught in schools. Further, teachers rarely instruct students in how to study and, even when they do, their advice is often wrong. For example, some study guides and websites argue that repeated study of one subject until it is "mastered" is the best way to study. It isn't.

Cognitive psychologists have discovered three principles that, used in isolation or, better yet, in combination, greatly aid learning. These strategies can be used in classroom settings or while students study on their own, are useful for nearly any kind of material, and are free (no fancy software needed). Yet, despite these advantages, the techniques are rarely used.[1]

The first strategy is retrieval practice, which refers to testing oneself on material that has been learned. For example, if a student has just read a passage in her history book, closing the book for a few minutes and recalling the information to herself would greatly help her consolidate and remember it later. Retrieval practice is typically more beneficial compared to control conditions, such as reading the passage once or even reading it twice.[2] Retrieval practice also usually produces much greater learning on delayed tests compared to restudying.[3] Despite its robust advantages, few students hit upon the strategy on their own. Most university students report rereading of material as their preferred study strategy.[4]

Another important strategy is spacing repetitions of information that students seek to learn. "Burning it in" by back-to-back study does not work well for long-term learning. Spacing study sessions is generally better, and the longer the spacing, the greater is learning for the long term.[5] Yet again, students often prefer to mass their study of a single topic to try to get it all at once without realizing the benefits of spacing.

Related to spacing is interleaving of study attempts. Consider math students learning to solve problems, such as how to find the volume of several solids. The nearly universal way of teaching such problems is to provide the formula for one type of solid (e.g., a wedge). Students learn the formula and then practice finding the volume of perhaps ten wedges. Then the students move on to learning about computing the volume of another solid (e.g., a spherical cone) and practice that one, before moving on to the next. This standard method is called blocked practice and it is also massed (i.e., no spacing between solutions). A different way of learning is by shuffling or interleaving practice. In this system, students are instructed in solving all the problems at the outset with minimal initial practice. Then they are given examples of different solids and they have to solve for the volume. One advantage of interleaving is that it teaches students how to discriminate among the problem types – "What type of solid is this?" – whereas blocked training does not. Students find interleaved practice difficult – they learn more slowly and may never achieve the

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among clinicians (N=1485), confidence is only weakly associated (r=.15) with accuracy on judgmental and prediction tasks, such as violence prediction and psychiatric diagnosis.[15] Many people commonly, and often erroneously, rely on the *confidence heuristic*, a mental shortcut that regards confidence as a valid indicator of competence.[15]

Consistent with research on the "better than average effect," whereby people believe themselves to be better than others on most attributes, psychotherapists seem to be as susceptible to overconfidence as everyone else. For instance, one study reported that the average clinician rated him- or herself at the 80th percentile of skill level and effectiveness among all clinicians; one quarter placed themselves at the 90th percentile.[16] *None* considered themselves below average. These cheery self-views may engender pernicious consequences, because most therapists substantially underestimate the proportion of their clients who are deteriorating during treatment.[17]

Regrettably, many laypersons apparently assume that science and intellectual humility are contradictory. Googling the phrase "science is arrogant" returns approximately 1,400 entries. This intuitive belief probably stems from a confusion between *scientists* and *science*.[18] Data suggest that scientists, especially highly creative ones, are more confident, dominant, and even arrogant than nonscientists.[19] Still, even though some scientists themselves are conceited, the scientific community operates to keep them in check, relentlessly pushing back against their unsubstantiated claims. As McFall observed, science is a systematic prescription for intellectual humility, reminding us that our inferences may be in error.[20]

Because of the scant scientific attention accorded to intellectual humility, a plethora of questions remain. On the assessment front, self-reports of intellectual humility seem likely to have their limitations. Intellectually humble people may be unaware of or reluctant to admit to their modesty, while intellectually arrogant people may be oblivious of their lack of it. It will therefore be essential to assess intellectual humility using additional modes of assessment, especially informant reports. Further, the extent to which the correlates of intellectual humility are attributable to general intelligence are unclear. On the etiological front, we know precious little about the sources of intellectual humility and the personality, cognitive, and attitudinal variables that shape its emergence.

Finally, on the intervention front, we know virtually nothing about the extent to which intellectual humility can be modified in adulthood or cultivated in childhood. In one study, fostering a "growth mindset" toward intelligence, which holds that cognitive ability can be fostered via concerted effort, yielded significant boosts in intellectual humility in adults.[10] Although this investigation offers provisional evidence that intellectual humility is malleable in the short term, more research is needed to determine the extent to which this trait is amenable to long-term intervention. Given that an awareness of one's biases is a key barometer of wisdom and perhaps a protective factor against ideological extremism,[21] few scientific endeavours would appear to be more pressing for the forthcoming generation of psychologists.

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level of performance as with blocked practice. However, several studies (in labs and classrooms) have shown that interleaved learning (mixing questions for the different solids) leads to better learning.[6,7] On a test given later, students who learned by interleaving maintain their level of performance, whereas those who study by blocking seem to have forgotten the solutions.

For students studying on their own, all three techniques we have recommended could be used simultaneously. Students can use retrieval practice (inherent in flashcards), they can space out their learning over days and weeks, and they can interleave topics. These techniques have all been shown to lead to more durable learning than the type of study students often prefer (and teachers often recommend): massed repetition that seems to make learning faster and easier, but which leads to rapid forgetting over time. The only caveat is that, when using flashcards and other similar techniques, students must continue to practice over widely spaced intervals to ensure that the knowledge is stable. Forgetting happens, and researchers have shown that students often choose to drop a card from the deck after getting it right once or twice when this is not sufficient practice.[8]

Many studies in the lab and the classroom show that these techniques can also be adapted for use in learning bodies of text. One such study asked whether questions inserted into a textbook chapter led to better retention through retrieval practice (with correct answer feedback) or whether having the questions at the end of the chapter was better (again with feedback). One of the control conditions was simply reading the answers without getting the questions at comparable placements. Retrieval practice led to greater recall than simply rereading the answers (61.5% to 44.8%), and the position of the questions did not matter on a test given two days later.[9] However, asking questions both within the chapter and afterwards led to the best recall (65.4%), probably due to spaced retrieval practice.

In summary, learning can be enhanced by using these three straightforward strategies that have been shown to work by decades of research.[10] Yes, retrieval practice, spacing and interleaving take a bit of work on the part of students and teachers, but they help lead to durable learning in ways that the typical strategies, such as massed practice, fail to do. Students and teachers can improve learning by redesigning courses and study schedules to better incorporate these proven methods.

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References, links and resources

[1] Galasiu, A. D., Newsham, G. R., Suvagau, C., & Sander, D. M. (2007). Energy saving lighting control systems for open-plan offices: a field study. *LEUKOS, 4*(1), 7-29.

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References, links and resources

[1] Troyer, A. K. (2001). Improving memory knowledge, satisfaction, and functioning via an education and intervention program for older adults. *Aging, Neuropsychology, and Cognition, 8,* 256-268. doi:10.1076/anec.8.4.256.5642.

[2] Wiegand, M. A., Troyer, A. K., Gojmerac, C., & Murphy, K. J. (2013). Facilitating change in health-related behaviours and intentions: A randomized controlled trial of a multidimensional memory program for older adults. *Aging and Mental Health, 17,* 806-815. doi:10.1080/13607863.2013.789000

[3] Vandermorris, S., Au, A., Gardner, S., & Troyer, A. K. (in preparation). A ten hour memory strategy training and brain health lifestyle coaching workshop can increase adaptive memory strategy use and health-promoting lifestyle behaviours in cognitively normal community-dwelling older adults: A randomized controlled trial.

[4] Vandermorris, S., Davidson, S., Au, A., Sue, J., Fallah, S., & Troyer, A. K. (2017). "Accepting where I'm at" - A qualitative study of the mechanisms, benefits, and impact of a behavioural memory intervention for community-dwelling older adults. *Aging and Mental Health, 21,* 895-901. doi:10.1080/13607863.2016.1181709

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References, links and resources

1. Roediger, H. L., & Pyc, M. A. (2012). Inexpensive techniques to improve education: Applying Cognitive Psychology to enhance educational practice. *Journal of Applied Research in Memory and Cognition, 1*, 242-248.
2. Roediger, H. L., & Karpicke, J. D. (2006). Test-enhanced learning: Taking memory tests improves long-term retention. *Psychological Science, 17*, 249-255.
3. Karpicke, J. D., & Roediger, H. L. (2008). The critical importance of retrieval for learning. *Science, 319*, 966-968.
4. Karpicke, J. D., Butler, A. C., & Roediger, H. L. (2009). Metacognitive strategies in student learning: Do students practice retrieval when they study on their own? *Memory, 17*, 471-479.
5. Carpenter, S. K., Cepeda, N. J., Rohrer, D., Kang, S. H. K., & Pashler, H. (2012). Using spacing to enhance diverse forms of learning: Review of recent research and implications for instruction. *Educational Psychology Review*, *24*, 369-378.
6. Kang, S. H. K. (2017). The benefits of interleaved practice for learning. In J. C. Horvath, J. Lodge, & J. A. C. Hattie (Eds.), *From the laboratory to the classroom: Translating science of learning for teachers* (pp. 79-93). New York: Routledge.
7. Rohrer, D. (2012). Interleaving helps students distinguish among similar concepts. *Educational Psychology Review*, *24*, 355-367.
8. Karpicke, J. D. (2009). Metacognitive control and strategy selection: Deciding to practice retrieval during learning. *Journal of Experimental Psychology: General, 138*, 469-486.
9. Uner, O., & Roediger III, H. L. (in press). The effect of question placement on learning from textbook chapters. *Journal of Applied Research in Memory and Cognition.*
10. Brown, P.C., Roediger, H. L, & McDaniel, M.A. (2014). *Make It Stick: The Science of Successful Learning* Cambridge, MA: Harvard University Press.

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References, links and resources

Kahneman, D. (2011). *Thinking, fast and slow* (p. 114). New York: Farrar, Straus and Giroux.

Lilienfeld, S.O., Lynn, S.J., O'Donohue, W.T., & Latzman, R.D. (2017). Epistemic humility: An overarching educational philosophy for clinical psychology programs. *The Clinical Psychologist, 70*, 6-14.

Samuelson, P.L., Church, I.M., Jarvinen, M., & Paulus, T. (2013). *The science of intellectual humility* [White paper].

Meehl, P. E. (1990). Schizotaxia as an open concept. In A. I. Rabin, R. A. Zucker, R. A. Emmons, & S. Frank (Eds.), *Studying persons and lives* (pp. 248-302). New York: Springer.

Pap, A. (1953). Reduction-sentences and open concepts. *Methodos, 5*, 3-30.

Leary, M.R., Diebels, K.J., Davisson, E.K., Jongman-Sereno, K.P., Isherwood, J.C., Raimi, K.T., Deffler, S.A., & Hoyle, R.H. (2017). Cognitive and interpersonal features of intellectual humility. *Personality and Social Psychology Bulletin, 43*, 793-813.

Pronin, E., Lin, D. Y., & Ross, L. (2002). The bias blind spot: Perceptions of bias in self versus others. *Personality and Social Psychology Bulletin, 28*, 369-381.

West, R.F., Meserve, R.J., & Stanovich, K.E. (2012). Cognitive sophistication does not attenuate the bias blind spot. *Journal of Personality and Social Psychology, 103*, 506-519.

Lewis, C.S. (1952). *Mere Christianity*. San Francisco: HarperCollins.

Porter, T., & Schumann, K. (2018). Intellectual humility and openness to the opposing view. *Self and Identity, 17*, 139-162.

Krumrei-Mancuso, E.J., & Rouse, S.V. (2016). The development and validation of the comprehensive intellectual humility scale. *Journal of Personality Assessment, 98*, 209-221.

Davis, D.E., Rice, K., McElroy, S., DeBlaere, C., Choe, E., Van Tongeren, D.R., & Hook, J.N. (2016). Distinguishing intellectual humility and general humility. *The Journal of Positive*